Land Use/Land Cover Change Detection using remote sensing and GIS approach in Sawangi watershed of Yavatmal district, Maharashtra, India

ABSTRACT

Land cover is a physical appearance of land, representing its ecological status. It is dynamically changed due to human interventions, natural disturbances and successions. The research extent of such changes needs to be known for better land use planning decisions. Land use land cover changes during the period of 2008 to 2017 were analyzed usings geographical information system (GIS) and remote sensing data were used to determine the changes based on time-series of Landsat satellite imagery in Sawangi watershed of Yavatmal district, Maharashtra. The comparison of each class of study over these years showed a significant change in land use and land cover. The result showed that there was a high increase in five land cover types, namely: current fallows (12.5 %), wasteland (2.34 %), habitation (0.07 %), industrial area (0.23 %) and water bodies (0.36 %). Contrarily, there was declension in three land cover types, namely: agriculture (12.7 %), shrub land (2.77 %), and forest (9 %). These finding will help in deciding land use planning for future in the watershed.

Key words: Land use land cover, Remote sensing, GIS, Change detection, Sawangi watershed.

1.Introduction:

"Information on land use/land cover (LULC) in the form of maps and statistical data is very vital for spatial planning, management and utilization of land for agriculture, forestry, pasture, industrial, environmental studies, economic production etc". (Roy and

Giriraj, 2008). “Land Use Land Cover (LULC) changes and climatic change in conjunction with soil deterioration alter the hydrological cycle, thereby progressively degrading the ecosystem and reducing the quality of land resources, biodiversity, and agriculture” (Bajocco *et al.* 2012). “Due to rapid industrialization and increasing demographic pressure in India, natural resources are being over-exploited, precipitating a critical resource management challenge with shrinking agricultural lands and a rise in wasteland and hydrological crisis” (Government of India, Ministry of Agriculture and Farmers Welfare: Department of Agriculture, 2016). “The field area chosen for this study is one of the critical climate vulnerable hot semi-arid zones of India (approximately 1/4th of the Aurangabad district, which is part of the Maharashtra State in western India). The study area is semi-arid in nature and is marked by very low summer monsoon rainfall (2012-2015), with low ground water table and water-stressed agricultural activity” (Ratna, 2012). “Studies have indicated that semi-arid regions are particularly stressed due to the combined effects of a burgeoning population and climate change” (Mukherjee *et al*. 2009).

“Land use and land cover change are perhaps the most prominent form of global environmental change since they occur at spatial and temporal scales immediately relevant to our daily existence” (CCSP, 2003). “Technically, land use and land cover change mean quantitative changes in areal extent (increase or decrease) of a given type of land use and land cover respectively. Land use and land cover change are a manifestation of forces both anthropogenic and environmental – climate-driven factors” (Liu *et al*, 2009). “The changes in land use in various spatial and temporal domains are the material expressions, and also indicate environmental and human dynamics and their interactions mediated by land availability” (Lambin *et al*. 2003)

“Remote sensing (RS) and photogrammetric techniques provide spatially explicit, digital data representations of the earth’s surface that can be combined with digitized paper maps in Geographic Information System (GIS) to allow efficient characterization and analysis of vast amounts of data. Satellite remote sensing, in conjunction with GIS, has proved to be an extremely useful tool for natural resource management". Kalra et al. (2010). Kalra *et al*. (2010) stated that "integration of remote sensing within a GIS database can decrease the cost, reduce the time and increase the detailed information gathered for soil survey". "Application of remotely sensed data made possible to study the changes in land cover in less time, at low cost and with better accuracy" (Pandian *et al.* (2014).

"Geographical information systems (GIS) and remote sensing are well-established information technologies, the value of which for applications in land and natural resources management are now widely recognized. They are, however, still essentially separate technologies and practitioners still generally consider themselves primarily involved with one or the other" (Qiming Zhou, 1995). "GIS has been defined as a powerful set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes" (Burrough, 1986). "GIS enables effective and efficient manipulation of spatial and non-spatial characterization and mapping of soils for the benefit of local people" (Star *et al*. 1997). "In recent years, the application of GIS has increased many folds in various fields. The introductions of GIS promoted inter disciplinary studies, both within the natural, environmental, social and economic sciences. Its applications have expanded rapidly in parallel with advances in remote sensing and provides infrastructure for the examination of complex spatial problems in new and exciting ways" (Asadi *et al.* 2012).

Therefore, the main objective of this research was identifying and delineating the different LULC categories and the pattern of land use change in Sawangi watershed of Yavatmal district, Maharashtra, using Landsat satellite imagery from 2008 to 2017. Its Second objectives determining the change in LULC categories by spatial comparison of the LULC maps produced. and the third objectives of suitable land use planning for future in the watershed.

2. MATERIAL AND METHODS

Study area

“The Sawangi watershed area is located between 20^o 15’ 47” to 20^o 20’ 42” N latitude and 77^o 35’ 27” to 77^o 42’ 54” E longitude, The elevation ranges from 161 to 356 m (WGS 84 datum) above mean sea level (AMSL). which covers an area of 11777.62 ha in Yavatmal district, Maharashtra. The average annual rainfall of 917.36 mm (decennial average of 2008-2017), out of which maximum rainfall (85.95 %) is received during rainy season (late June to October) and 3.14 per cent during winter (December to February). The climate is mainly hot moist to semiarid type with annual mean maximum and minimum temperatures of 33.8 ^oC and 23.31 ^oC respectively. Soil moisture regime is ustic and hyperthermic soil temperature regime (Soil Survey Staff 2014)”. [17]

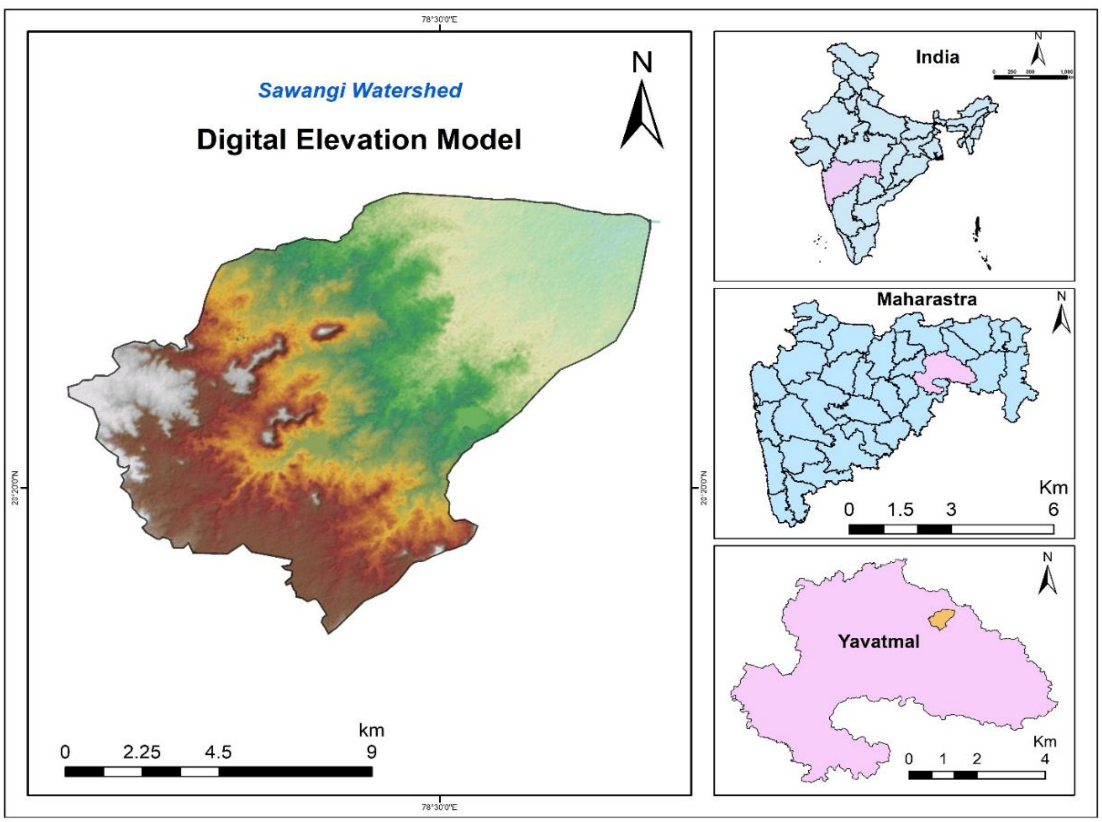


Fig. 1 Location map of Sawangi watershed

The geology of the study area is covered by Deccan trap formation known as basalt flows, which belongs to Sahyadri group of Ajanta and Chikhli formations. (District Resource Map, Yavatmal District, Maharashtra of Geological survey of India, 2001). In these areas crops such as cotton, soybean, pigeon pea, sorghum, gram, wheat, and vegetables. The basalt flows are generally dark grey, massive, fine to medium grained and non to moderately porphyritic with few flows of highly porphyritic nature (District Resource Map, Yavatmal District, Maharashtra of Geological survey of India, 2001). The recent alluvium occurs in the river valley. The basalt of the area is mainly of two types, *viz*., massive, and vesicular basalt. The vesicular basalts are filled up with secondary minerals like silica, zeolite and calcite.

Data collection

Satellite data, physical data and ancillary data were used in the present study. Physical data included cadastral map of each village in the watershed and revenue records of land holdings, crops grown during the preceding year (2016-17), population details etc. Survey of India (SOI) toposheet on 1:50,000 scale (55 H/13) was used to collect topographical information. This toposheet was used as base map for location of sample areas, ground truth sites and planning for traverse routes in the field and other details. Ancillary data included ground truthing for the land cover/use classes and topographic maps. The ground truth data were in the form of reference data points collected using Geographical Positioning System (GPS). Satellite data for the three different years on the other hand consisted of multi-spectral data acquired by Landsat satellite for the month of February - April provided by USGS glovis. Specifications of the satellite data acquired for change analysis are given in Table 1.

Table 1 Details of remote sensing data used in the present study:

S. NO.	Satellite Sensors	Resolution (m)	Month of acquisition	Image Type
1.	LANDSAT- 5 (TM)	30m	March 2008	Level-1 GeoTIFF
2.	LANDSAT-5	30m	February 2012	Level-1 GeoTIFF

	(TM)			
3.	LANDSAT-8 (OLI)	30m	February 2017	Level-1 GeoTIFF

Table 2. Data source used for the study:

Data	Source
• Digital Elevation Model (30 m resolution)	United States Geological Survey
• Satellite Sentinel – 2 (10 m resolution)	European Space Agency
• Soil data on 1:50000	National Bureau Soil Survey and Land Use Planning
• Geomorphology on 1:50000	Maharashtra Remote Sensing Application Centre
• Satellite image	Google Earth

Data used in this research comprised three cloud-free Landsat (TM-5 and OLI-8) images, which were collected on March 2008, February-2012 and March 2017. All three images were obtained from the USGS Earth Explorer Landsat archive and geometrically corrected and rectified to UTM zone 49. Were used for visual interpretation to assess the classification process. The standard false colour composite (FCC) was generated by bands 2,3 and 4 using arc GIS software (10.4.1) Satellite images of the area are shown in figures 2, 3 and 4 The details of the imagery used in investigation are given in the Table 2.

The soil data at 1:10000 scale collected through detailed survey were used for hydrological grouping and overlaid. The effect of LULC changes based on ground truth data and visual interpretation.

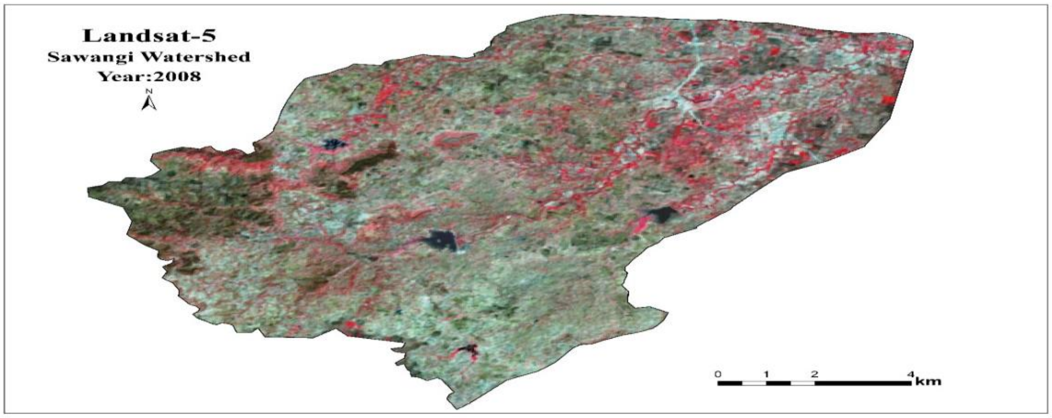


Fig. 2 Satellite data of Sawangi watershed (2008)

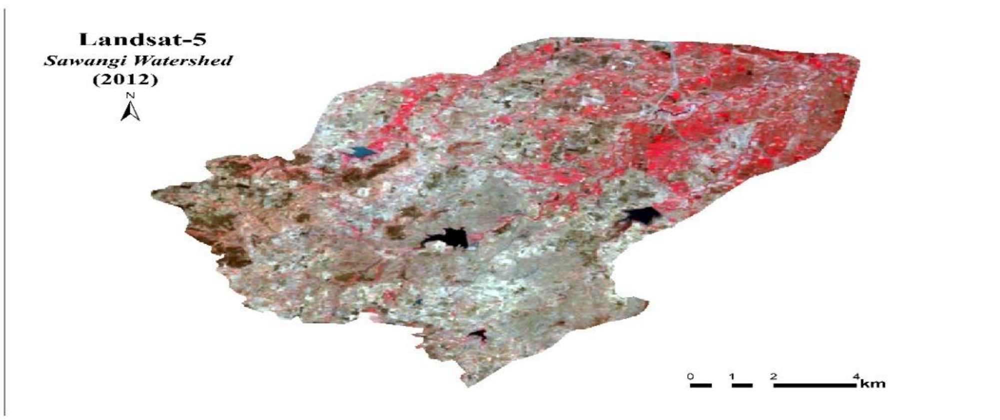


Fig. 3 Satellite data of Sawangi watershed (2012)

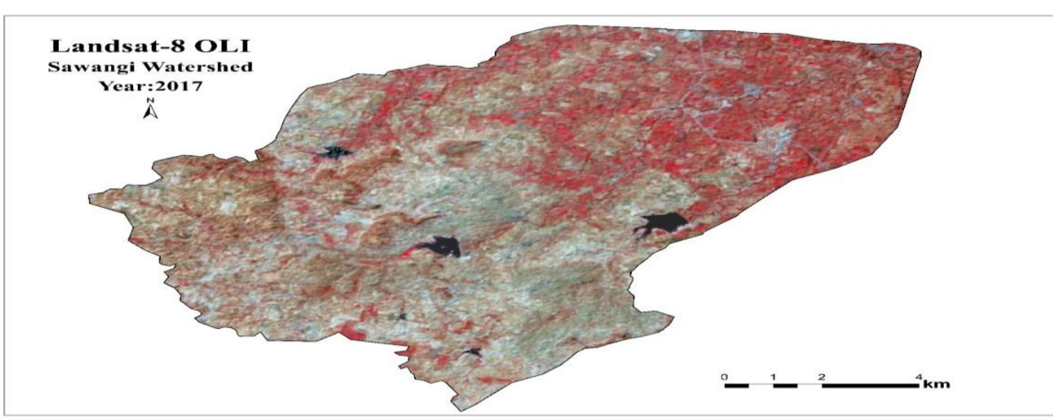


Fig. 4 Satellite data of Sawangi watershed (2017)

Land use/Land cover mapping:

Land use/land cover provides information about the current land use and forms the baseline information for sustainable land use planning and rural development. (Krishna *et al*., 1999). Remote sensing and GIS are more effective tools for mapping the land use land cover and vegetation. (Skidmore *et al*., 1991). The cloud free satellite imagery was used to analyze the land use land cover (LULC) of different years. Temporal satellite images (2008, 2012 and 2017) as detailed in Table 3. were acquired for analysis in Geographic Information System (GIS) platform. The following steps have been put for the preparation of the land use/land cover map.

- Orientation of satellite imagery with the context to Landsat satellite images.
- Land use/land cover details on the Landsat-5 and Landsat-8 satellite images.
- Interpretation of geocoded FCC using the image interpretation characteristics.
- Demarcation of notified forest area with the help of Landsat satellite images.
- Demarcation of water bodies.
- Development of legend key on the basis of the spectral behavior of land cover.
- Demarcation of land-use boundaries using Level-I.
- Collection of ground truth data for developing a correlation among the land use/land cover units and image characteristics.
- Validation and finalization of maps.
- Estimation of the area covered by varied classes.

Table 3. Details of remote sensing data used for preparing LULC map:

Primary data		
Watershed and Yavatmal district	Satellite data	United States Geological Survey, year 2008, 2012 and 2017 (Landsat -5 and Landsat -8 data, 30 m resolution) (https://earthexplorer.usgs.gov) European Space Agency, year 2017 (Sentinel -2 data, 10 m resolution) (https://scihub.copernicus.eu/dhus/home)

Table 4. Land use land cover classes description:

S. No.	Class name	Description
1	Agriculture	Crop fields
2	Fallow lands	Current fallow lands
3	Forest cover	Mixed forest lands
4	Wasteland Land	Land areas of exposed soil and barren area due to anthropogenic influence
5	Shrub land	Land covered with the small plants
6	Habitation	Residential, commercial, industrial
7	Water body	River, open water, lakes, ponds and reservoirs

3. RESULTS AND DISCUSSION

Land use / land cover distribution

LULC classes were identified and delineated by visual interpretation, Landsat-5 and Landsat-8 satellite images. The delineated classes were agriculture, current fallow, habitation, forest cover, shrubland, wasteland, industrial area and waterbody. The area under different land use/land cover classes with image characteristics are presented in (Table 5). The Sawangi watershed is classified in which LULC maps were generated for different years 2008, 2012, and 2017 using satellite data at 1:50,000 scale and showed Figure 5, 6, 7, 8, 9 & 10. The distribution of various LULC classes and their area statistics was calculated using maps which are showed Table 6.

The LULC of Sawangi watershed is dominated by agriculture, wasteland, and current fallows lands of the total geographical area of the watershed. The investigated results showed that wasteland, habitation, and industrial area increased continuously between 2008 to 2017, while forest land and shrub land which is a forest degradation class has been decreased continuously between 2008 to 2017. The current fallows land has continuously increased between 2008 to 2017. The agriculture land has been decreased continuously between 2008 to 2017.

Table 5 Land use / land cover distribution (2008, 2012 & 2017)

LULC class	2008		2012		2017	
	Area (ha.)	**Area (%)**	**Area (ha.)**	**Area (%)**	**Area (ha.)**	**Area (%)**
Agriculture land	5926.46	50.32	5347.59	45.40	4436.5	37.67
Current fallows	1510.40	12.82	2144.88	18.21	2983.0	25.33
Wasteland	2292.12	19.46	2390.72	20.30	2567.1	20.80
Shrub land	1272.90	10.81	1002.01	8.51	946.3	8.03
Forest cover	329.45	2.80	320.11	2.72	319.0	2.71
Industrial Area	1.17	0.01	22.27	0.19	28.8	0.25
Habitation	73.37	0.62	75.69	0.64	82.1	0.70
Waterbody	371.75	3.16	474.36	4.03	414.7	3.52
TGA	11777.62	100	11777.62	100	11777.6	100

(**TGA** = Total Geographical Area)

The land use and land cover change comparison of each class over different years was presented in Table 6. During the year of 2008 to 2017 area under agriculture, class decreased by 1489.93 ha (12.65%). The decline of agriculture class in the watershed area was due to construction mainly by an industrial area and habitation and the area around the water bodies in the watershed has shifted from a wasteland into an agricultural area. During the 2008 to 2017 area under fallow land class increased by 1472.63 ha (12.50 %).

The decline of fallow land class in the watershed area was due to converted of fallow land into industrial areas and wasteland. It has also been seen in the study area that the industrial or habitation areas are mostly surrounded by agricultural areas, especially in the catchment area. it means that the area near the residential area has been cleared for the production of crops in order to fulfill the necessities of life. During the field survey, it was observed by the investigation that wastelands around the villages have also been utilized under cultivation land.

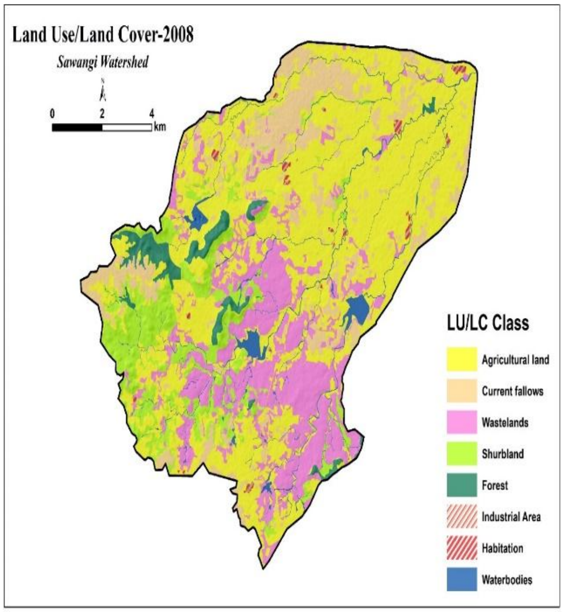


Fig 5. LULC of Sawangi watershed (2008)

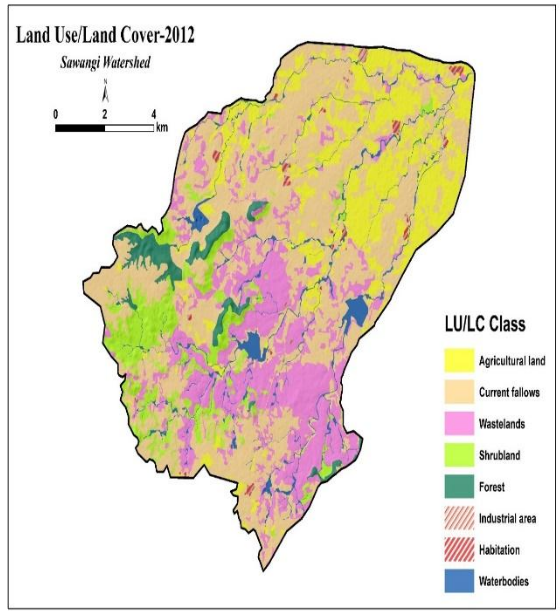


Fig 6. LULC of Sawangi watershed (2012)

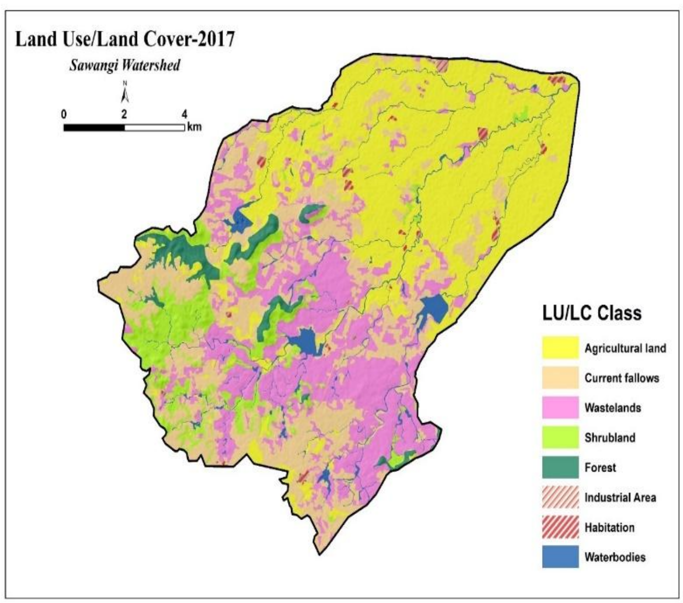


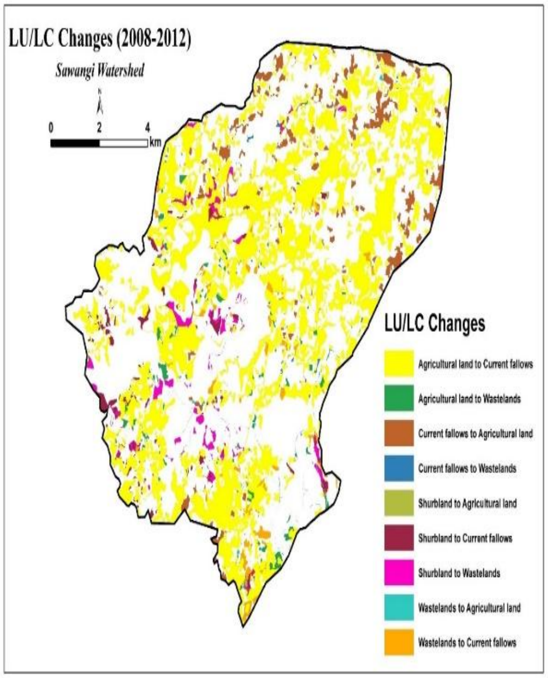
Fig 7 LULC of Sawangi watershed (2017)

It was observed by ground truthing from 2008 to 2017 that some of the forest and shrubland areas were decreased by 10.42 ha and 326.58 ha, which was shifted into cultivated

Table 6. LULC change detection

LULC class	2008-2012		2012-2017		2008-2017	
	Area (ha)	(%) Change	Area (ha)	(%) Change	Area (ha)	(%) Change
Agriculture	-578.88	-4.9	-911.06	-7.7	-1489.93	-12.7
Current fallows	634.48	5.4	838.15	7.1	1472.63	12.5
Wasteland	98.60	0.84	176.42	1.50	275.02	2.34
Shrub land	-270.89	-2.30	-55.70	-0.47	-326.58	-2.77
Forest	-9.34	-0.08	-1.08	-0.01	-10.42	-0.09
Industrial Area	21.10	0.18	6.56	0.06	27.66	0.23
Habitation	2.31	0.02	6.39	0.05	8.70	0.07
Waterbody	102.61	0.87	-59.68	-0.51	42.93	0.36

lands due to encroachment by the farmers and habitation. while during 2008 to 2017 that some of the habitation and industrial areas increased by 8.70 ha and 27.66 ha. This was attributed to population growth and increased housing requirements by the people of the study area. The classification results revealed that the wasteland area increased by 275.02 ha from 2008 to 2017. The increase of wasteland in the watershed area was due to converted of fallow land and shrubland into the wasteland. Water bodies area 42.93 ha increased from 2008 to 2017 and decreasing by 59.68 ha from 2012 to 2017.



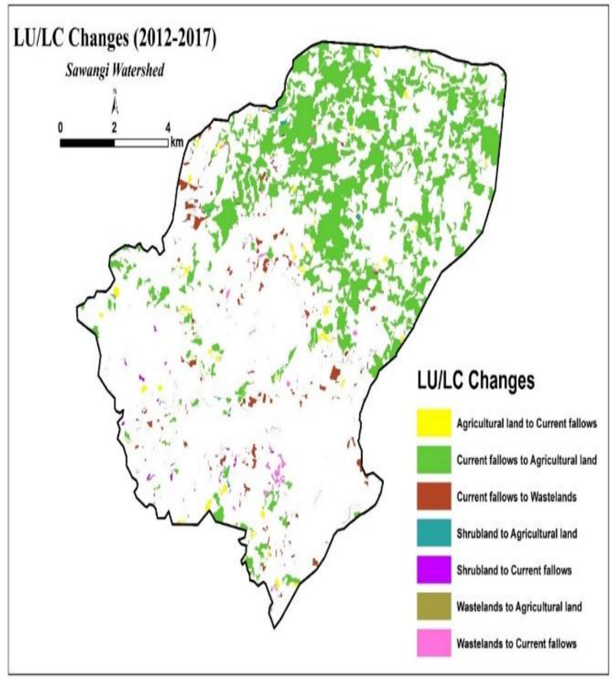


Fig. 8 LULC changes (2008-12)

Fig. 9 LULC changes (2012-17)

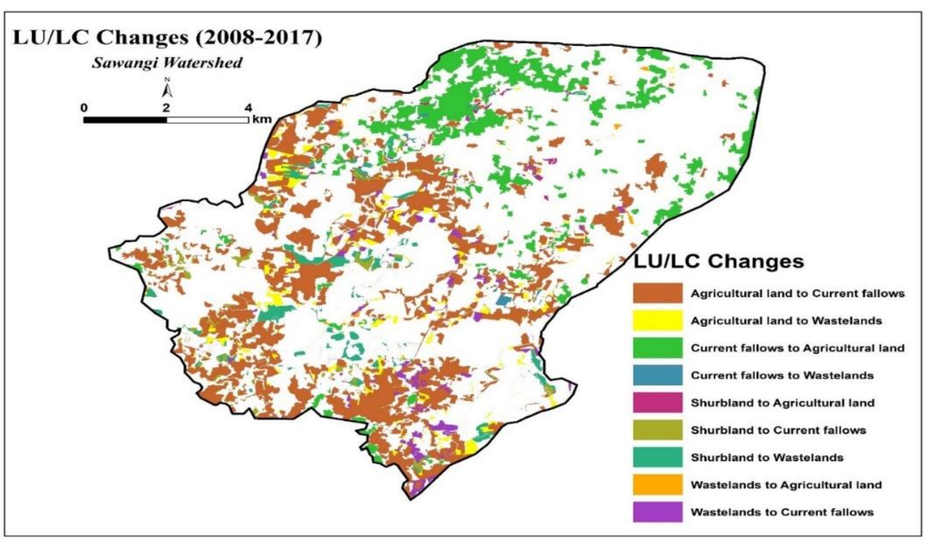


Fig. 10 LULC changes in the Sawangi watershed (2008-17)

Discussion

As per the conversion in various land use/land cover types observed during the year 2008 to 2017 in study areas shown in fingers 8, 9 and 10, there is evidence it was constantly decline in agriculture land 1489.93 ha (-12.65 %), forest land 10.42 ha (- 0.09 %) and shrubland areas (-2.77 %) 326.58 ha respectively. while these are the land conversions into fallow land, industrial, habitation and wasteland due to construction work mainly encroachment by the farmers and habitation in highlighted in Tables 5 and 6 respectively. who attributed the loss of agriculture and forest areas over the last decades to several biophysical and socio-economic factors, namely, rapid urbanization, population growth and distribution, the influx of profit-oriented industries, agriculture, and infrastructure expansion. These results will help in future planning for land use and watershed development. It also showed that geospatial techniques are helpful for analyzing LULC dynamics and for sustainable land use planning.

4. CONCLUSION

This study assessed LULC changes and the dynamics based on the results obtained by employment the satellite remote sensing coupled with GIS can be a powerful tool for mapping and evaluation of land use/land cover changes of a given area., The results can be summarized were found to have experienced rapid changes in LULC from 2008 to 2017. that the land use and cover practices in the study area have altered significantly in 10 years. The agriculture areas decreased by approximately 1489.93 ha (12.7%) in watershed. The expansion of the agriculture land over the study area exhibited clear spatiotemporal differences due to increasing fallow land areas, the loss of agriculture and forest areas over the last decades to several biophysical and socio-economic factors, namely, rapid urbanization, population growth and distribution, However, these trends need to be closely monitored for the sustainability of environment in future.

In summary, information provided by satellite remote sensing and GIS data, along with ancillary data such as population data, can play a significant role in quantifying and understanding the relationship between population density and LULC changes. Furthermore, researching the nature of land use land cover changes can be aided and developed by analyzing the satellite data, such as, Landsat images can provide the rate, patterns and trend of changes using the benefit of repetitive satellite coverage on a particular locality. Such information is essential for further land use planning and the sustainability of environment in future.

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